PCT
WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04L 29/06 | A2

(11) International Publication Number: WO 97/40610

(43) International Publication Date: 30 October 1997 (30.10.97)

(21) International Application Number: PCT/CA97/00269

(22) International Filing Date: 23 April 1997 (23.04.97)

(30) Priority Data:
60/015,945 24 April 1996 (24.04.96) US

(71) Applicant: NORTHERN TELECOM LIMITED [CA/CA]; World Trade Center of Montreal, 8th floor, 380 St. Antoine Street West, Montreal, Quebec H2Y 3Y4 (CA).

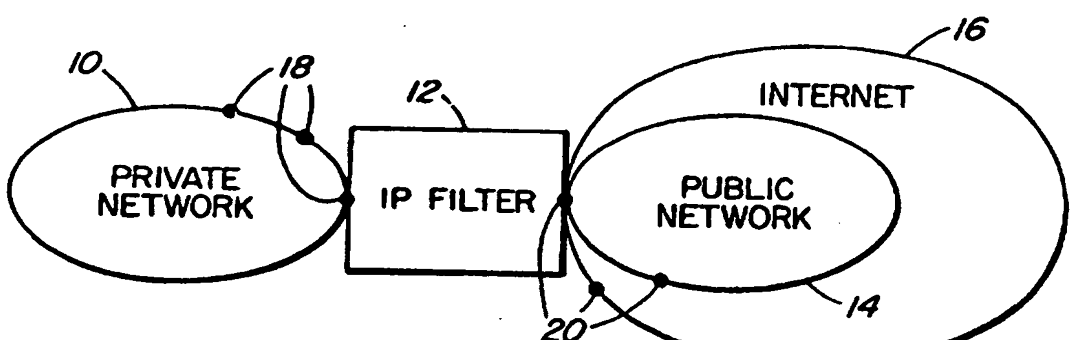
(72) Inventors: WOOTTON, Bruce, Anthony; 10601 Bent Twig Drive, Raleigh, NC 27613 (US). COLVIN, William, G.; 874 Childs Drive, Milton, Ontario L9T 4J6 (CA).

(74) Agent: GRANCHELLI, John, A.; Northern Telecom Limited, Patent Dept., P.O. Box 3511, Station "C", Ottawa, Ontario K1Y 4H7 (CA).

(81) Designated States: AU, CA, CN, JP, KR, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: INTERNET PROTOCOL FILTER



(57) Abstract

The IP filter (12), embodying the present invention, is a communications device designed to provide public network (14) or Internet (16) access to nodes (18) of private networks (10), advantageously without requiring the private nodes on such networks to register public Internet addresses. The IP filter presents a single IP address to the Internet and uses a plurality of IP ports to solve the problem of IP address conservation. It initiates sessions by assigning private side IP sessions to a unique port of the IP filter's public address. The IP filter effects a translation between a source port number for the private network and a destination port number for the public network for communication therebetween. Benefits of the IP filter include private node security and conservation of Internet-registered addresses.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

INTERNET PROTOCOL FILTER

Background Of The Invention

The present invention generally relates to inter-network firewalls and, in particular, to an internet protocol (IP) filter whereby a private IP network domain is mapped to a single IP address on the public Internet.

Firewalls are generally known and characterized by computer servers which function to couple nodes within the domain of the private network to nodes in a public network domain, such as the Internet. A deficiency of the known firewall products is the need for a unique public IP address for each concurrent session or interaction between public and private nodes.

A firewall providing conservation of public IP addresses would be desirable.

Summary Of The Invention

It is an object of the present invention to provide a new and improved apparatus for communicatively coupling two networks.

The invention, therefore, according to a first exemplary aspect provides a method of interfacing private and public data communications networks, through a filter node in communication with both networks, the filter node having an address known in the public network, comprising the steps of: routing from nodes in the private network, to the filter node, data packets having destination information, which includes a destination address and a destination port, corresponding to nodes in the public network and having source information, which includes a source address and a source port, of the respective private network nodes; for each data packet received from the private network, at the filter node, maintaining the source information taken from the data packet in correlation with a unique value representing a port of the filter node, and replacing in the data packet the source address with the filter node address and the source port with the filter node port value; and routing from the filter node, in the

public network, the data packets having the replaced source information, according to the destination information in each, to the corresponding public network nodes.

According to a second exemplary aspect, the invention provides a method of interfacing private and public data communications networks, through a filter node in communication with both networks, comprising the steps of: (a) receiving at the filter node, from the private network, a data packet having an a destination address corresponding to a node in the public network and a source address corresponding to a node in the private network; (b) maintaining, by the filter node, the source address taken from the data packet; (c) replacing, in the data packet, the source address with an address of the filter node; (d) routing from the filter node, in the public network, the data packet having the replaced source address, according to the destination address, to the corresponding public network node; (e) waiting for a return packet from the public network, responsive to the data packet having the replaced source information; (f) replacing, in the return packet, the destination address with the maintained source address; and (g)routing from the filter node, in the private network, the return packet having the replaced destination address to the corresponding private network node.

According to a third exemplary aspect, the invention provides a method of operating a filter node for interfacing first and second data communications networks, comprising the steps of: receiving from the first network, a data packet having destination information, which includes a destination address and a destination port, corresponding to a node in the second network and having source information, which includes a source address and a source port, corresponding to a node in the first network; maintaining the source information taken from the data packet in correlation with a unique value representing a port of the filter node; replacing in the data packet the

source address with an address of the filter node and the source port with the filter node port value; and sending to the second network the data packet having the replaced source information, whereby that packet is routed according to its destination information to the corresponding second network node.

According to a fourth exemplary aspect, the invention provides a filter node for interfacing first and second data communications networks, comprising: means for receiving from the first network, a data packet having destination information, which includes a destination address and a destination port, corresponding to a node in the public network and having source information, which includes a source address and a source port, corresponding to a node in the first network; means for maintaining the source information taken from the data packet in correlation with a unique value representing a port of the filter node; means for replacing in the data packet the source address with an address of the filter node and the source port with the filter node port value; and means for sending to the second network, the data packet having the replaced source information, whereby that packet is routed according to its destination information to the corresponding second network node.

An IP filter, embodying the present invention, is a communications device designed to provide public network or Internet access to nodes of private networks, advantageously without requiring the private nodes on such networks to register public Internet addresses. The IP filter presents a single IP address to the Internet and uses a plurality of IP ports to solve the problem of IP address conservation. It initiates sessions by assigning private side IP sessions to a unique port of the IP filter's public address whereby up to 64,512 (= 65,536 total - 1,024 well known ports) concurrent sessions may be supported through the single IP address. The IP filter effects a translation between a source port number for the

private network and a destination port number for the public network for communication therebetween. Benefits of the IP filter include private node security and conservation of Internet-registered addresses.

In a particular embodiment, the IP filter may support three data transport protocols over the internet protocol: transmission control protocol (TCP), user datagram protocol (UDP) and Internet control message protocol (ICMP). Packets of other protocols may be ignored.

The TCP protocol prepends a TCP header to a data packet. The source port and destination port numbers are contained in this header. The Internet addresses of the source and destination nodes are contained in the IP header. The IP address and port information extracted from each packet will be used to determine where the IP filter should route this packet.

The IP filter maintains a lookup table of information on each TCP connection. This information includes the port from the private node, the private IP address, the assigned port number of the destination node, and the port number of the IP filter in the form of an index. When a packet is received from the private network, the private address and port number are added to the table as a new entry, if an entry corresponding to this packet is not found in the table and if the TCP header indicates that this is a new connection request. Then the source address and port number in the packet header are replaced with the IP filter's IP address and port number, and the packet is transmitted to the Internet.

When the IP filter receives a packet from the Internet, the destination port number is used to index the lookup table. When the corresponding table entry is found, the destination address and port number are replaced with the private network's IP address and port number, and the packet is transmitted to the private network. If the received packet's source port is different from the port

recorded in the table, and if the packet header information indicates that this packet is the first response on the connection, then the lookup table is updated with the port number assigned by the Internet node, if needed. When the IP filter detects an end of transmission code in the packet, the lookup table entry is zeroed. If the IP filter receives packets from the Internet that do not have entries in the lookup table corresponding to the IP filter port, it ignores the packets.

The UDP protocol is connectionless, as opposed to TCP, a connection-oriented protocol. The UDP header contains no codes governing initial connection or end of transmission. The data of interest in the UDP header are the source port and destination port. This information, along with the Internet addresses contained in the IP header, are used to determine where the IP filter should route this packet.

The IP filter maintains a lookup table of information on each UDP session. When the IP filter receives a UDP packet from the private network, it records the source address, the source port number, the destination port number, and the assigned IP filter port number as the index to the table. Then the private node address and port number in the packet header are replaced with the address and assigned port number of the IP filter. Then the packet is transmitted to the Internet.

When the IP filter receives a UDP packet from the Internet, it indexes the UDP lookup table and replaces the packet's destination information, namely the IP filter address and assigned port number, with the private address and port number from the lookup table. The lookup table also maintains an interval indication for an expiration timer on datagram packets received as per standard UDP implementations. If the IP filter receives packets from the Internet that do not have entries in the lookup table corresponding to the IP filter port, it ignores the packets.

As ICMP packets do not contain port numbers of either source or destination, any ICMP packets received from the private network are processed one at a time, with buffering of additional ICMP packets. The IP filter reads the private address from the packet header and replaces it with the address of the IP filter. The packet is transmitted to the Internet, and the IP filter waits for the response. When it receives the responding packet, the destination address in the packet header is changed from that of the IP filter to that of the node on the private network. Then the IP filter transmits the packet to the private network.

To successfully deliver packets over an IP protocol network, each node must maintain a table of other hosts' IP addresses and their corresponding Ethernet addresses in an Ethernet based data communications network. The nodes actually use the IP addresses and the Ethernet addresses to address packets. The relationship between the two addresses is dynamic; that is, a node with an IP address may change its Ethernet address. The information in the address table is obtained from the replies to the node's broadcast of ARP packets. The source node broadcasts ARP packets to request the Ethernet address of the destination node, given the destination node's IP address. If the destination node receives the packet, it sends a reply packet with the requested information.

Though it does not maintain a true ARP table, the IP filter passes ARP packets in a manner similar to TCP and UDP packet passing. When the IP filter receives an ARP packet from a node on the private network destined for the public network, it replaces the source address information with the filter's address information. The private node's IP address and the target IP address are placed in a lookup table. When the target node replies with its own Ethernet address, the destination address information is changed from that of the IP filter to that of the private node before transmitting the packet to the private node. The

private node address information is obtained from the table. When an ARP packet is destined for the firewall, the ARP packet does not pass through the IP filter but is restricted to communications between the filter and the one side of the network.

Events and errors encountered by the IP filter may be logged, for example, by writing them into a text file.

The IP filter ideally will process packets as fast as the networks present them but when network traffic is too heavy, the IP filter will then buffer the packets in two queues, one for the private network and one for the Internet.

Two source and destination lookup tables may be utilized, one for TCP packets and the other for UDP packets. Each table is directly indexed by the IP filter port number assigned to the communication session. The table entries contain the IP address of the private node, the source port of the private node, and the destination port of the Internet node. If there is no connection on a certain IP filter port, then the corresponding entry in the table may be zeroed. Packets arriving from both the private network and the Internet are processed using the same lookup table. This arrangement assumes that of the available IP filter communications ports some are designated for UDP communication and some for TCP communication.

Brief Description Of The Drawings

The invention will be better understood from the following description together with reference to the accompanying drawings, in which:

Figure 1 is a schematic representing an internet protocol filter coupling a private network and a public network; and

Figure 2 is a block diagram representing internal components of the filter.

Detailed Description

Referring to Figure 1, shown for illustration of

the present invention is a private network 10 communicatively coupled through an internet protocol (IP) filter 12 to a public network 14 which may form part of a global data network, otherwise referred to as the Internet 16. The private network 10 represents a conventional data communications network, such as a local area network (LAN), having a plurality of nodes 18 each being identified by a unique IP address within the domain of the private network 10. The public network 14 and Internet 16 are representative of public domain data communications networks also having a plurality of nodes 20 with corresponding IP addresses.

The IP filter 12 acts as a gateway through which data packets are exchanged between the private network 10 and the public network 14, thereby providing Internet access to the nodes 18 of the private network 10. The IP filter 12 constitutes one of the private network nodes 18 and is the only such node to have a public IP address that is Internet-registered, whereby the IP filter 12 essentially also constitutes one of the public nodes 20 and its IP address is known in the public domain. The IP addresses of the other private network nodes 18 are reserved for the private network 10, and not known or registered in the public Internet address domain. As is conventional, associated with the IP address of the IP filter 12 are a plurality of IP ports, specifically 65,536 in total of which 64,512 are not reserved for predefined protocols and can be used for address translations.

Communications between nodes 18 on the private network 10 are unaffected by the presence of the IP filter 12, but to access the public network 14 and particularly the nodes 20 therein, the private nodes 18 route all communications requests through the IP filter 12. The IP filter 12 manages the communications between private nodes 18 and the Internet nodes 20 by modifying header information of data packets received from the private network 10 before transmitting each to the public network

14. The modifications cause the communications between the private nodes 18 and the public Internet nodes 20 to actually be between the IP filter 12 and the Internet nodes 20, which route all return communications to the IP filter 12 which subsequently routes the return data packets to the private nodes 18.

The IP filter 12 accepts no connection requests from the public network 14. All communications between private nodes 18 and public nodes 20 are initiated by the private nodes 18. The IP filter 12 is designed to support three data transport protocols over the internet protocol: TCP, UDP and ICMP messages; packets of other protocols are rejected or ignored.

A translation table is maintained by the IP filter 12 to map address and ports for packets received from the private network 10 destined to the public network 14 and vise versa. The translation table contains the following for each entry:

private IP address	(pIP)
private port	(pPort)
internet (public) IP address	(iIP)
internet (public) Port	(iPort)
timer	
session type/state	
Ethernet address	

The basic translation substitutes IP addresses and ports from the private network side to the IP filter's IP address and ports, thereby hiding all nodes 18 on the private network 10 from the public network 14.

A packet originating on the private network side specifies a source - destination of

(pIP, pPort - iIP, iPort)

This defines a "socket" in which the endpoints of the connection (source and destination) are defined by the IP addresses in the IP header and the ports in the TCP or UDP header.

The IP filter 12 will translate the above to

(frIP, frPort - iIP, iPort)

where frIP is the IP address of the IP filter 12 on the public network 14, and frPort is the index into the translation table plus an offset value, for example, of 1024 to skip using well known ports. The frPort represents an arbitrary port.

The internet node 20 will reply with a packet

(iIP, iPort - frIP, frPort)

which will be received by the IP filter 12 and translated thereby to

(iIP, iPort - pIP, pPort)

In general, to translate from the private side, the values (protocol type, pIP, pPort, iIP, iPort) must be located in the translation table. This should be done with a hash table lookup.

Translating from the public side can be a direct table lookup since frPort minus 1024 is the index into the table. If (iIP, iPort) in the packet does not match the corresponding entries in the table, then an unauthorized access is logged and the packet dropped.

In translating packets, when a port is substituted in the TCP or UDP header, the checksum in both the TCP/UCP and IP header must be recalculated. When an IP address is substituted in the IP header, the IP header checksum must be recalculated.

Following are special considerations for different protocols supported by the IP filter 12.

In respect of TCP, when a SYN packet is received from the private network 10, the IP filter 12 locates an unused entry in the table and fills it in, setting the type to TCP and state to SYN. Then the packet is forwarded by the general scheme above. If no free entries exist in the table, then the packet is dropped and the event is logged.

If a SYN packet is received from the public network 14 interface, it is treated as unauthorized and logged (except for FTP special case described below). However, a SYN+ACK packet is forwarded if the state of the

translation table entry is SYN. After forwarding such a packet the state set to OPEN.

If a FIN packet is received by the IP filter 12 and if the state in the translation table is not FIN, the state is set to FIN and the packet forwarded. If the state is FIN, then the packet is forwarded and the translation table entry is deleted by setting it to 0. A FIN must be sent by each side to close a TCP connection.

If a RST packet is received, then the translation table entry is deleted.

Having regard now to the UDP protocol, when any UDP packet is received from the private network 10 side, the IP filter 12 first tries its standard lookup. If a translation table entry is not found, an unused entry is set up and the state set to OPEN. If a free entry is not found in the table, then rather than dropping the packet, a random UDP in the table is overwritten. Since UDP is connectionless and consequently an unreliable transport, if a packet is received from the public network 14 that would have needed the entry that was overwritten, that packet will be dropped and the node 18 on the private side will need to retry.

With regard to FTP, an FTP client establishes a TCP "control" connection with an FTP server on a particular port, for example, port 21. However, when data is to be transmitted, the FTP server will open a TCP connection from its "data" port, for example, which is default 20, to a destination port specified by the client.

To support this, packets sent by the private network 10 to port 21 need to be analyzed for an FTP "port" command at the IP filter 12. If detected, then a new entry in the table must be set up with pPort set to the value in the FTP port command. The IP address and port number in the FTP command must be changed to the IP filter's address and port before forwarding the packet. The state is set to FTPDATA.

When a SYN packet is received from the public

network 14, if a table entry exists and is in FTPDATA state, then the packet is forwarded and the state set to OPEN.

For the ICMP protocol, if an ICMP packet is received from the private network 10 and if that packet is an echo request (ping), then the IP filter 12 locates a new entry in the translation table. The sequence field of the packet is stored in pPort in the table and the table index is put in the sequence field of the packet. The ICMP checksum is recalculated and the standard IP header substitution is done. The type is set to ICMP and state to PING and the timer set to 1 minute.

If an echo reply (ping) is received from the public network 14 interface, then the sequence field is used as the index into the table. If the state is PING, then pPort in the table is substituted into the sequence field of the packet, the ICMP checksum recalculated and the standard IP header substitution is done. The table entry is then deleted.

If an echo request (ping) is received from the public network 14, then the IP filter 12 will reply. This allows internet access to confirm that the IP filter 12 is reachable and running.

If a Destination Unreachable packet is received from the public network 14, then the header information contained is extracted. If the protocol was TCP or UDP, the (frIP, frPort - iIP, iPort) of the originating packet can be determined and the translation table entry located. If the IP address extracted from the ICMP matches the address in the table, the IP filter 12 forwards the packet to the private network 10 using the standard scheme.

All other ICMP packets received from either side are dropped and logged.

Since most data communications protocols are based on either the UDP or TCP protocols, these other protocols are compatible with the IP filter 12 as long as they do not initiate negotiations like FTP to have the server open a

connection back to the client. Examples of other compatible protocols include: Telnet; TFTP (Trivial File Transfer Protocol); DNS (Domain Name Services); and Web browsers.

Whenever a packet is transmitted in either direction, the timer field of the translation table entry is set to the configured timeout value (except ping). Each minute, the timer field of all active entries in the tables are decremented and if they become 0, then the translation table entry is deleted. This will clear out UDP and PING entries which are no longer in use and also TCP entries which have had an abnormal termination and did not send FIN from each side. It could be a security hole to leave an unused entry in the table for too long. A good timeout value to be configured would be just longer than the typical TCP keep alive.

According to a particular embodiment, the private network 10 and the public network 14 are Ethernet based LANs. The IP filter 12 may be implemented by a data processing platform which is equipped with two conventional Ethernet hardware interfaces connected to networks 10 and 14, respectively, and which is provisioned with appropriate software to implement the functionality of the IP filter 12.

Internal components of the IP filter 12 in terms of software executable by the data processing platform are shown in Figure 2. The internal components include two packet drivers 30 and 32, an address resolution protocol (ARP) table 34, an Ethernet address table 36, an IP handler 38, an address translation 40 and a user interface 42. The packet drivers 30 and 32 control the Ethernet hardware interfaces in order to communicate with, respectively, the private network 10 and the public network 14. The IP handler 38 provides a router functionality for receiving and forwarding messages, and maintains the ARP table 34 and the Ethernet table 36. The address translation 40 effects translation between source port numbers from the private

network 10 and the destination port numbers on the public network side 14. The user interface 42 enables an operator, via a keyboard and display terminal attached to the processing platform, to interface with the IP filter 12. Functions keys are provided to configure the IP filter, view or copy log files, display status, etc. The log file will contain the connect time of TCP or UDP sessions, inbound and outbound traffic statistics, and invalid access to the IP filter 12. To prevent the log file from growing too large, this information will be logged to a new file when the date changes.

Routing of packets to and from the IP filter 12 is described in the following in terms of a public interface, from the view of the public network 14, and of a private interface, from the view of the private network 10.

The public interface behaves as a host on the LAN segment. To forward a packet, it checks to see if the destination IP is on the local LAN segment. If it is, it looks up the IP address in its ARP table to find the Ethernet address. If there is no entry in the ARP table, it must put the packet on a queue and send out an ARP request to get the Ethernet address. Standard aging out of ARP table entries needs to be done. If the IP destination is not on the LAN segment, it will forward the packet to the configured default router. ICMP Redirect messages sent by the default router will be ignored.

The private interface effects the functionality of a router, as it needs to be able to forward packets to one or more routers to communicate with the remote client stations. A large remote client network may access multiple router machines. Conventional routing can result in large routing tables because the routing entries become host addresses instead of subnet addresses. That is, if the network is set up so that a client may come in through either Router1 or Router2, then no single router can be the router for the subnet that that client station is on. A conventional router that would get routing tables via RIP

from all routers on the private network would end up with a large table of host addresses for each remote client connected. This can affect performance in the search time necessary to find the route, the memory required for large tables and the amount of RIP traffic on the LAN segment between all these routers.

To handle routing in this environment, the IP filter will maintain an Ethernet table. For every packet that is forwarded from the private to public side, if a translation entry exists, use its Ethernet index to compare with the Ethernet source address of the incoming packet. If they match, nothing more needs to be done. Otherwise, the Ethernet table is searched for the source Ethernet address, adding a new Ethernet table entry if not found. The index to the Ethernet table is then saved in the translation table entry. Then when a packet is being translated from the public to private side, the Ethernet address can be retrieved directly from the index in the translation table. Thus packets will be routed to the router which forwarded the packet to the IP filter.

Those skilled in the art will recognize that various modifications and changes could be made to the invention without departing from the spirit and scope thereof. It should therefore be understood that the claims are not to be considered as being limited to the precise embodiments set forth above, in the absence of specific limitations directed to each embodiment.

WE CLAIM:

1. A method of interfacing private (10) and public (14) data communications networks, through a filter node (12) in communication with both networks, the filter node having an address known in the public network, comprising the steps of:

routing from nodes (18) in the private network, to the filter node, data packets having destination information, which includes a destination address and a destination port, corresponding to nodes (20) in the public network and having source information, which includes a source address and a source port, of the respective private network nodes;

for each data packet received from the private network, at the filter node, maintaining the source information taken from the data packet in correlation with a unique value representing a port of the filter node, and replacing in the data packet the source address with the filter node address and the source port with the filter node port value; and

routing from the filter node, in the public network, the data packets having the replaced source information, according to the destination information in each, to the corresponding public network nodes.

2. A method as claimed in claim 1, comprising the steps of:

routing from nodes in the public network, to the filter node, data packets each having the address of the filter node as the destination address;

for each data packet received from the public network, at the filter node, correlating the destination port of the destination information in the data packet to particular source information being maintained and replacing, in the data packet, the destination information with the particular source information;

routing from the filter node, in the private

network, the data packets having the replaced destination information to the corresponding private network nodes.

3. A method as claimed in claim 2, comprising ignoring by the filter node a data packet received from the public network, if the destination port of the destination information in that data packet can not be correlated to the maintained source information.

4. A method as claimed in claim 3, wherein maintaining the source information includes storing the source information from each data packet as an entry in a lookup table, and the filter node port value correlating to the source information constitutes an index into the table for that entry.

5. A method as claimed in claim 4, wherein the data packets include packets in accordance with a transmission control protocol (TCP) over an internet protocol (IP).

6. A method as claimed in claim 5, comprising receiving at the filter node a TCP packet from the private network; and if an entry corresponding to the TCP packet is not found in the lookup table and the TCP packet indicates that this is a connection request, storing the source information together with the destination information from the TCP packet as a new entry in the lookup table.

7. A method as claimed in claim 6, comprising receiving at the filter node a TCP packet from the public network; and if the source port in the received TCP packet is different from the destination port in a source information entry of the lookup table, indexed by the destination port in the TCP packet, and if the TCP packet indicates that this packet is a first response to the connection request, then updating by the filter node the destination port in the table entry with the source port

from the received TCP packet.

8. A method as claimed in claim 7, comprising receiving at the filter node a TCP packet having an end of transmission code in the packet and zeroing an entry in the lookup table corresponding to the received TCP packet.

9. A method as claimed in claim 4, wherein the data packets include packets in accordance with a user datagram protocol (UDP) over an internet protocol (IP).

10. A method as claimed in claim 9, comprising receiving at the filter node a UDP data packet from the private network, and adding the source information and the destination information from the UDP packet together with an interval indication for an expiration timer as a new entry in the lookup table.

11. A method of interfacing private (10) and public data (14) communications networks, through a filter node (12) in communication with both networks, comprising the steps of:

(a) receiving at the filter node, from the private network, a data packet having an a destination address corresponding to a node (20) in the public network and a source address corresponding to a node (18) in the private network;

(b) maintaining, by the filter node, the source address taken from the data packet;

(c) replacing, in the data packet, the source address with an address of the filter node;

(d) routing from the filter node, in the public network, the data packet having the replaced source address, according to the destination address, to the corresponding public network node;

(e) waiting for a return packet from the public network, responsive to the data packet having the replaced

source information;

(f) replacing, in the return packet, the destination address with the maintained source address; and

(g) routing from the filter node, in the private network, the return packet having the replaced destination address to the corresponding private network node.

12. A method as claimed in claim 11, comprising buffering, at the filter node, further data packets received from the private network while waiting for the return packet, and repeating steps (b) through (g) on an individual basis for the further packets, if any, that were buffered.

13. A method as claimed in claim 12, wherein the data packets include packets in accordance with an internet control message protocol (ICMP).

14. A method of operating a filter node (12) for interfacing first (10) and second (14) data communications networks, comprising the steps of:

receiving from the first network, a data packet having destination information, which includes a destination address and a destination port, corresponding to a node (20) in the second network and having source information, which includes a source address and a source port, corresponding to a node (18) in the first network;

maintaining the source information taken from the data packet in correlation with a unique value representing a port of the filter node;

replacing in the data packet the source address with an address of the filter node and the source port with the filter node port value; and

sending to the second network the data packet having the replaced source information, whereby that packet is routed according to its destination information to the corresponding second network node.

15. A method as claimed in claim 14, comprising the steps of:

receiving from the second network, a data packet having the address of the filter node as the destination address;

correlating the destination port of the destination information in the data packet to particular source information being maintained;

replacing, in the data packet, the destination information with the particular source information;

sending to the first network the data packet having the replaced destination information, whereby that packet is routed according to its destination information to the corresponding first network node.

16. A method as claimed in claim 15, comprising ignoring a data packet received from the second network, if the destination port of the destination information in that data packet can not be correlated to the maintained source information.

17. A method as claimed in claim 16, wherein maintaining the source information includes storing the source information from the data packet as an entry in a lookup table, and the filter node port value correlating to the source information constitutes an index into the table for that entry.

18. A method as claimed in claim 17, wherein the data packets include packets in accordance with a transmission control protocol (TCP) over an internet protocol (IP).

19. A method as claimed in claim 18, comprising receiving a TCP packet from the first network; and if an entry corresponding to the TCP packet is not found in the lookup table and the TCP packet indicates that this is a

connection request, storing the source information together with the destination information from the TCP packet as a new entry in the lookup table.

20. A method as claimed in claim 19, comprising receiving a TCP packet from the second network; and if the source port in the received TCP packet is different from the destination port in a source information entry of the lookup table, indexed by the destination port in the TCP packet, and if the TCP packet indicates that this packet is a first response to the connection request, then updating the destination port in the table entry with the source port from the received TCP packet.

21. A method as claimed in claim 20, comprising receiving a TCP packet having an end of transmission code in the packet, and zeroing an entry in the lookup table corresponding to the received TCP packet.

22. A method as claimed in claim 17, wherein the data packets include packets in accordance with a user datagram protocol (UDP) over an internet protocol (IP).

23. A method as claimed in claim 22, comprising receiving a UDP data packet from the first network, and adding the source information and the destination information from the UDP packet together with an interval indication for an expiration timer as a new entry in the lookup table.

24. A method of operating a filter node (14) for interfacing first (10) and second (14) data communications networks, comprising the steps of:

(a) receiving from the first network, a data packet having an a destination address corresponding to a node (20) in the second network and a source address corresponding to a node (18) in the first network;

(b) maintaining the source address taken from the data packet;

(c) replacing, in the data packet, the source address with an address of the filter node;

(d) sending to the second network the data packet having the replaced source address, whereby that packet is routed to the corresponding second network node;

(e) receiving a return packet from the second network, responsive to the data packet having the replaced source information;

(f) replacing, in the return packet, the destination address with the maintained source address; and

(g) sending to the first network the return packet having the replaced destination address, whereby that packet is routed to the corresponding first network node.

25. A method as claimed in claim 24, comprising buffering further data packets received from the first network while waiting for the return packet, and repeating steps (b) through (g) on an individual basis for the further packets, if any, that were buffered.

26. A method as claimed in claim 25, wherein the data packets include packets in accordance with an internet control message protocol (ICMP).

27. A filter node (12) for interfacing first (10) and second (14) data communications networks, comprising:

means for receiving from the first network, a data packet having destination information, which includes a destination address and a destination port, corresponding to a node (20) in the second network and having source information, which includes a source address and a source port, corresponding to a node (18) in the first network;

means for maintaining the source information taken from the data packet in correlation with a unique value representing a port of the filter node;

means for replacing in the data packet the source address with an address of the filter node and the source port with the filter node port value; and

means for sending to the second network, the data packet having the replaced source information, whereby that packet is routed according to its destination information to the corresponding second network node.

28. A filter node as claimed in claim 27, comprising:

means for receiving from the second network, a data packet having the address of the filter node as the destination address;

means for correlating the destination port of the destination information in the data packet to particular source information being maintained;

means for replacing, in the data packet, the destination information with the particular source information; and

means for sending to the first network the data packet having the replaced destination information, whereby that packet is routed according to its destination information to the corresponding first network node.

29. A method as claimed in claim 28, comprising means for ignoring a data packet received from the second network, if the destination port of the destination information in that data packet can not be correlated to the maintained source information.

30. A method as claimed in claim 29, wherein the means for maintaining the source information includes means for storing the source information from the data packet as an entry in a lookup table, and wherein the filter node port value correlating to the source information constitutes an index into the table for that entry.

31. A filter node (12) for interfacing first (10) and

second (14) data communications networks, comprising:

(a) means for receiving from the first network, a data packet having an a destination address corresponding to a node (20) in the second network and a source address corresponding to a node (18) in the first network;

(b) means for maintaining the source address taken from the data packet;

(c) means for replacing, in the data packet, the source address with an address of the filter node;

(d) means for sending to the second network the data packet having the replaced source address, whereby that packet is routed to the corresponding second network node;

(e) means for receiving a return packet from the second network, responsive to the data packet having the replaced source information;

(f) means for replacing, in the return packet, the destination address with the maintained source address; and

(g) means for sending to the first network the return packet having the replaced destination address, whereby that packet is routed to the corresponding first network node.

32. A filter node as claimed in claim 31, comprising means for buffering further data packets received from the first network while waiting for the return packet, and means for controlling means (b) through (g) on an individual basis for processing the further packets, if any, that were buffered.

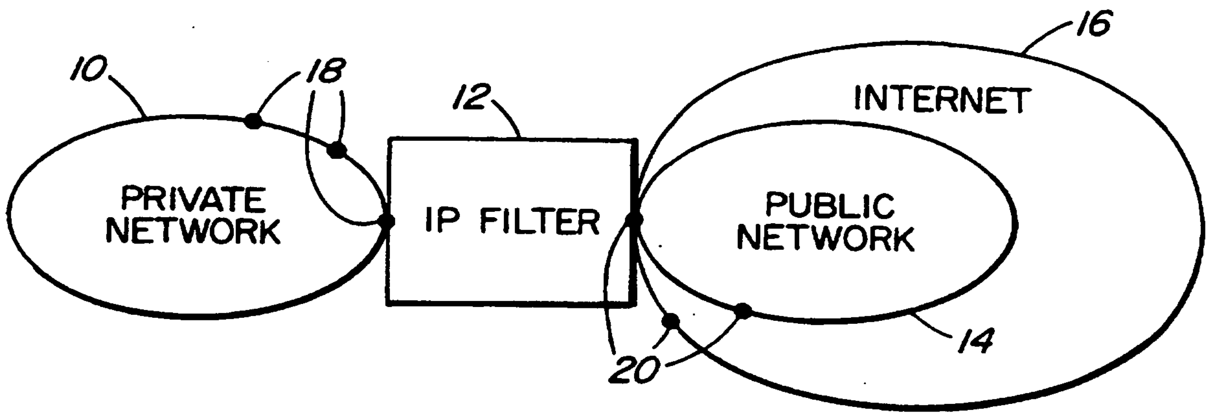

10
18
12
16
INTERNET
PRIVATE
NETWORK
IP FILTER
PUBLIC
NETWORK
20
14

FIG. 1

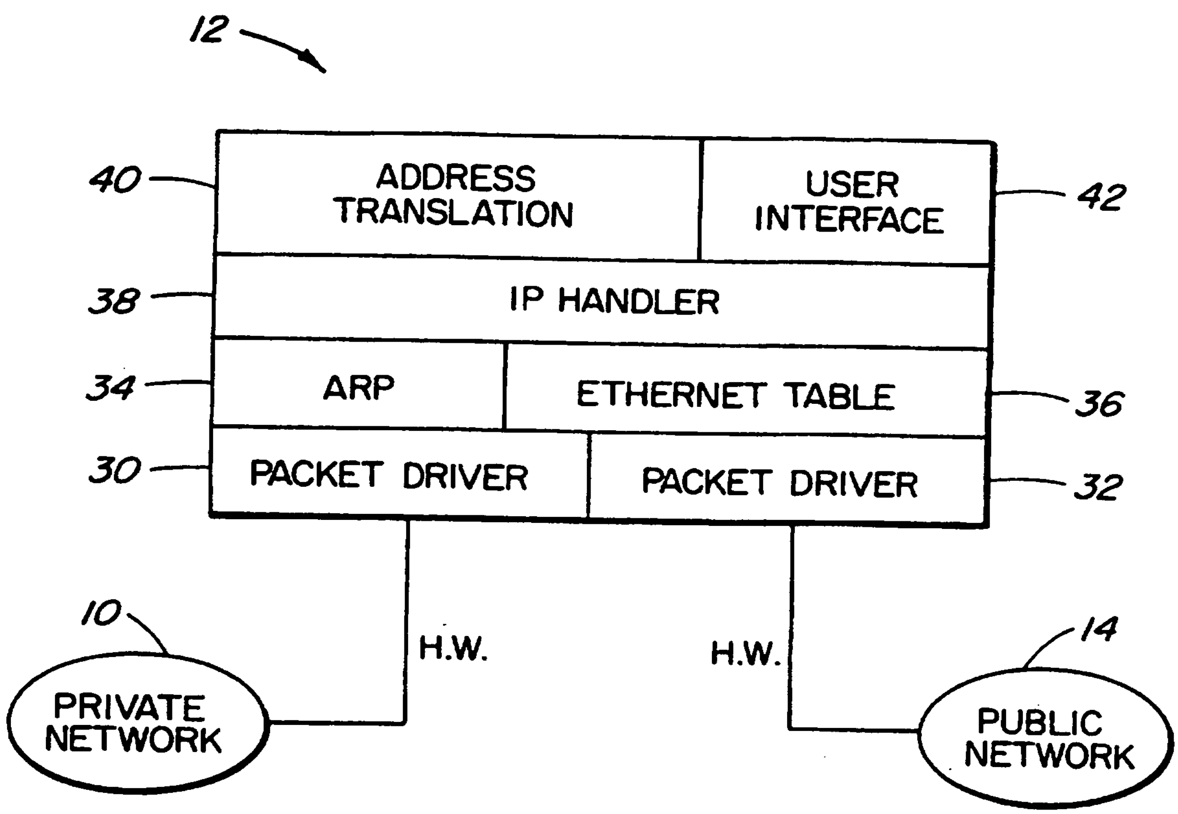

12
40
ADDRESS TRANSLATION
USER INTERFACE
42
38
IP HANDLER
34
ARP
ETHERNET TABLE
36
30
PACKET DRIVER
PACKET DRIVER
32
10
H.W.
H.W.
14
PRIVATE NETWORK
PUBLIC NETWORK

FIG. 2

INTERNATIONAL SEARCH REPORT

Intern. al Application No
PCT/CA 97/00269

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04L29/06 H04L12/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	RFC1631, May 1994, INTERNET ENGINEERING TASK FORCE, USA, pages 1-10, XP002040992 EGEVANG K AND FRANCIS P: "The IP Network Address Translator (NAT)" see paragraph 2; figures 1,2 see paragraph 3.3 ---	1,11,14, 24,27,31
A	EP 0 465 201 A (DIGITAL EQUIPMENT CORP) 8 January 1992 see column 7, line 30 - column 8, line 27 see column 10, line 45 - column 12, line 22; figure 2 ---	1,11,14, 24,27,31

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

11

Date of the actual completion of the international search	Date of mailing of the international search report
19 September 1997	14.10.1997

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Dupuis, H

Form PCT/ISA/210 (second sheet) (July 1992)

Inter nal Application No
PCT/CA 97/00269

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	INTERNET SECURITY HANDBOOK, 1995, MAIDENHEAD,ENGLAND, pages 27-37, XP002040993 STALLINGS W: see page 31; figure 3.2 -----	11,24,31

11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/CA 97/00269

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0465201 A	08-01-92	US 5309437 A	03-05-94
		CA 2044363 A	30-12-91
		DE 69122439 D	07-11-96
		DE 69122439 T	15-05-97

Form PCT/ISA/210 (patent family annex) (July 1992)

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04L 29/06, 12/46 — A3

(11) International Publication Number: WO 97/40610

(43) International Publication Date: 30 October 1997 (30.10.97)

(21) International Application Number: PCT/CA97/00269

(22) International Filing Date: 23 April 1997 (23.04.97)

(30) Priority Data:
60/015,945 24 April 1996 (24.04.96) US

(71) Applicant: NORTHERN TELECOM LIMITED [CA/CA]; World Trade Center of Montreal, 8th floor, 380 St. Antoine Street West, Montreal, Quebec H2Y 3Y4 (CA).

(72) Inventors: WOOTTON, Bruce, Anthony; 10601 Bent Twig Drive, Raleigh, NC 27613 (US). COLVIN, William, G.; 874 Childs Drive, Milton, Ontario L9T 4J6 (CA).

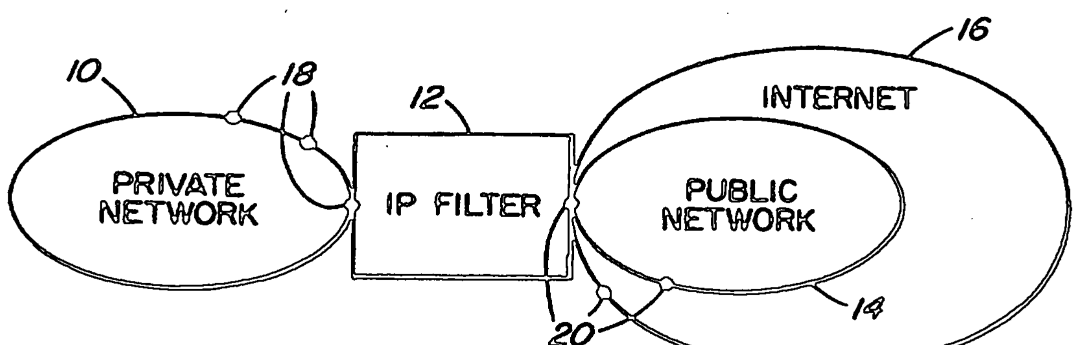
(74) Agent: GRANCHELLI, John, A.; Northern Telecom Limited, Patent Dept., P.O. Box 3511, Station "C", Ottawa, Ontario K1Y 4H7 (CA).

(81) Designated States: AU, CA, CN, JP, KR, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(88) Date of publication of the international search report: 27 November 1997 (27.11.97)

(54) Title: INTERNET PROTOCOL FILTER



(57) Abstract

The IP filter (12), embodying the present invention, is a communications device designed to provide public network (14) or Internet (16) access to nodes (18) of private networks (10), advantageously without requiring the private nodes on such networks to register public Internet addresses. The IP filter presents a single IP address to the Internet and uses a plurality of IP ports to solve the problem of IP address conservation. It initiates sessions by assigning private side IP sessions to a unique port of the IP filter's public address. The IP filter effects a translation between a source port number for the private network and a destination port number for the public network for communication therebetween. Benefits of the IP filter include private node security and conservation of Internet-registered addresses.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

INTERNATIONAL SEARCH REPORT

Intern. al Application No
PCT/CA 97/00269

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04L29/06 H04L12/46

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	RFC1631, May 1994, INTERNET ENGINEERING TASK FORCE, USA, pages 1-10, XP002040992 EGEVANG K AND FRANCIS P: "The IP Network Address Translator (NAT)" see paragraph 2; figures 1,2 see paragraph 3.3 ---	1,11,14, 24,27,31
A	EP 0 465 201 A (DIGITAL EQUIPMENT CORP) 8 January 1992 see column 7, line 30 - column 8, line 27 see column 10, line 45 - column 12, line 22; figure 2 --- -/--	1,11,14, 24,27,31

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

11

Date of the actual completion of the international search	Date of mailing of the international search report
19 September 1997	14.10.97

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+ 31-70) 340-3016	Dupuis, H

INTERNATIONAL SEARCH REPORT

Inte[illegible]nal Application No
PCT/CA 97/00269

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	INTERNET SECURITY HANDBOOK, 1995, MAIDENHEAD,ENGLAND, pages 27-37, XP002040993 STALLINGS W: see page 31; figure 3.2 -----	11,24,31

11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/CA 97/00269

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0465201 A	08-01-92	US 5309437 A	03-05-94
		CA 2044363 A	30-12-91
		DE 69122439 D	07-11-96
		DE 69122439 T	15-05-97